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FACULTY OF ELECTRICAL ENGINEERING

ETIMA 2021

FIRST INTERNATIONAL CONFERENCE

19-21 OCTOBER, 2021

TECHNICAL SCIENCES APPLIED IN ECONOMY, EDUCATION AND INDUSTRY

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UNIVERSITY „GOCE DELCHEV” - SHTIP
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PREFACE

The Faculty of Electrical Engineering at University Goce Delcev (UGD), has organized the International Conference ***Electrical Engineering, Informatics, Machinery and Automation - Technical Sciences applied in Economy, Education and Industry-ETIMA*.**
ETIMA has a goal to gather the scientists, professors, experts and professionals from the field of technical sciences in one place as a forum for exchange of ideas, to strengthen the multidisciplinary research and cooperation and to promote the achievements of technology and its impact on every aspect of living. We hope that this conference will continue to be a venue for presenting the latest research results and developments on the field of technology.
Conference ETIMA was held as online conference where contributed more than sixty colleagues, from six different countries with forty papers.
We would like to express our gratitude to all the colleagues, who contributed to the success of ETIMA'21 by presenting the results of their current research activities and by launching the new ideas through many fruitful discussions.
We invite you and your colleagues also to attend ETIMA Conference in the future. One should believe that next time we will have opportunity to meet each other and exchange ideas, scientific knowledge and useful information in direct contact, as well as to enjoy the social events together.

The Organizing Committee of the Conference

ПРЕДГОВОР

Меѓународната конференција ***Електротехника, Технологија, Информатика, Машинство и Автоматика-технички науки во служба на економија, образование и индустрија-ЕТИМА*** е организирана од страна на Електротехничкиот факултет при Универзитетот Гоце Делчев.
ЕТИМА има за цел да ги собере на едно место научниците, професорите, експертите и професионалците од полето на техничките науки и да представува форум за размена на идеи, да го зајканува мултидисциплинарното истражување и соработка и да ги промовира технолошките достигнувања и нивното влијание врз секој аспект од живеењето. Се надеваме дека оваа конференција ќе продолжи да биде настан на кој ќе се презентираат најновите резултати од истражувањата и развојот на полето на технологијата.
Конференцијата ЕТИМА се одржа online и на неа дадоа свој допринос повеќе од шеесет автори од шест различни земји со четириесет труда.
Сакаме да ја искажеме нашата благодарност до сите колеги кои допринесоа за успехот на ЕТИМА'21 со презентирање на резултати од нивните тековни истражувања и со лансирање на нови идеи преку многу плодни дискусии.

Ве покануваме Вие и Вашите колеги да земете учество на ЕТИМА и во иднина. Веруваме дека следниот пат ќе имаме можност да се сретнеме, да разменime идеи, знаење и корисни информации во директен контакт, но исто така да уживаме заедно и во друштвените настани.

Организационен одбор на конференцијата

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INRUSH CURRENT OF LAMP

Peter Janiga[1], Marek Mokran[2]
[1]Slovak University of Technology in Bratislava, Faculty of Electrical Engineering and Information Technology, email: *peter.janiga@stuba.sk*
[2]Slovak University of Technology in Bratislava, Faculty of Electrical Engineering and Information Technology, email: *marek.mokran@stuba.sk*

Abstract
Lighting systems pass through big change in terms of light source recently. LED replace discharge lamp and this change represent change of electrical parameters and influence to installations. Lighting systems with discharge lamp use inductive ballasts with choke and starter or electronic ballasts. Lamps with LED use drivers which are switching sources. The drives include rectifier, high frequency oscillator, transformer and capacitors. Typically, rectifier has impact to distortion of luminaire current and capacitor has impact to inrush current. Over the last years, problem increases with inrush current. Public lighting networks reconstruct with LED luminaires. Often increase inrush current and circuit-breaker must be changed for stronger. This change cause increasing of payment for energy distribution and sometime is necessary change installation. Aim of this paper is describe difference between luminaires from point of view inrush current. Size and duration of inrush current depends on construction of driver and on phase of supply voltage. In paper are analyzed amplitudes, durations and behavior of electrical parameters various LED luminaires.

Key words
LED, lamp, driver, inrush current

Introduction

Describes Lamps are quantitatively important group of consumers. Therefore, the question about optimizing their operations is still topical problem. In this context, operator efforts to reduce consumption and costs associated with maintenance and lighting system. In the past, thermal light source was dominated and for start it or operation of this lamp was not necessary driver or ballast. With discharge lamps using appear ballasts and later to reduce losses classic ballast pass to electronic ballast. Recently, LED light sources entered to using in interior and exterior lighting systems. When LED lamp is powered up from distribution network (for example 230 V AC) then lamp need driver for voltage and current stabilization.

1. Literature review

Driver is electronic circuit shown schematically in the figure below. In term of transients the peaks of current are during start up. Switching affects depend on size of the capacitor in DC side of bridge rectifier. His rapid charging cause increased value of start up current.

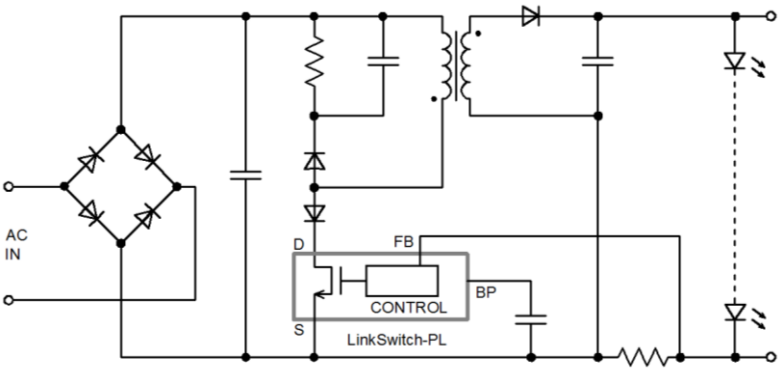
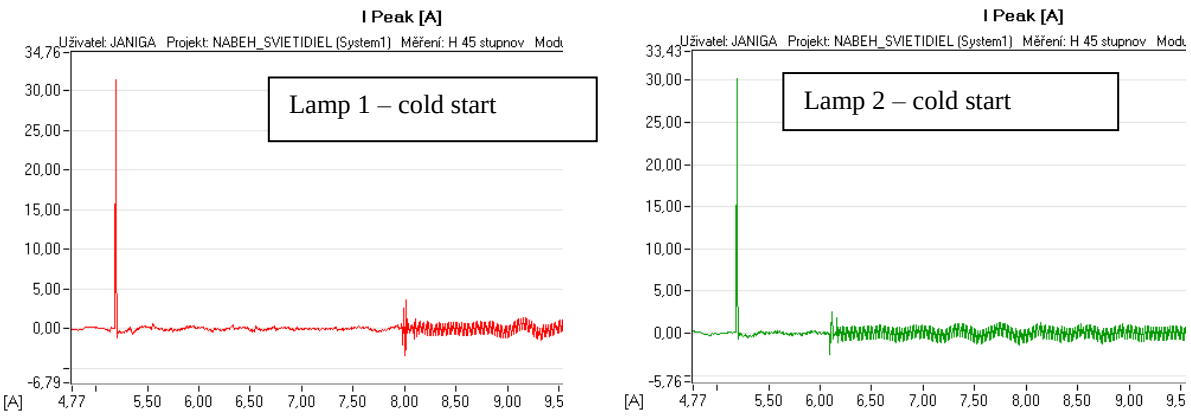


Fig. 1 Scheme of components in driver for LED lamp

Next transient is during driver output LED load connection. This transient is much smaller and its size and delay depending on lamp type. Delay between first and second transient is less than one second usually. The second current increase is about half of first transient. Size and time when current peaks come are depending on the driver construction, used LED modules, capacitor discharge (re-start) and phase of voltage when turning on the lamp. In the case driver with harmonic filter may be the size of starting current depends on inductance and capacitance of this filter also [5].

2. Inrush current LED lamp with driver

During the start of a lamp with LED driver occur two transients. Fig 2 shows behavior of two different lamps starts and shows what a difference may be when lamp start from normal status (cold start) and when lamp is restarted (hot start). The upper waveforms show start from cold status and bottom waveforms show start from warm-up lamp. During these measurements were phase and size of voltage identical. The aims of these measurements are show the differences of delay between first and second current peak.



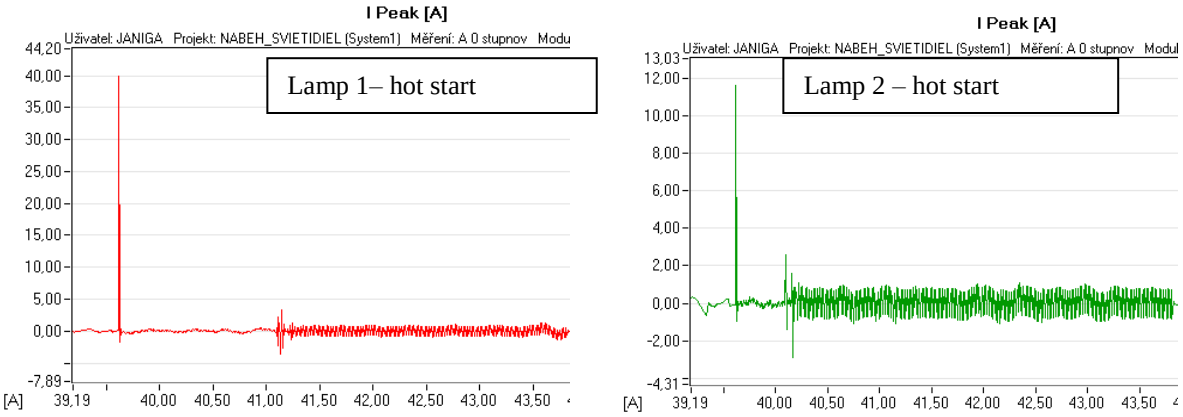
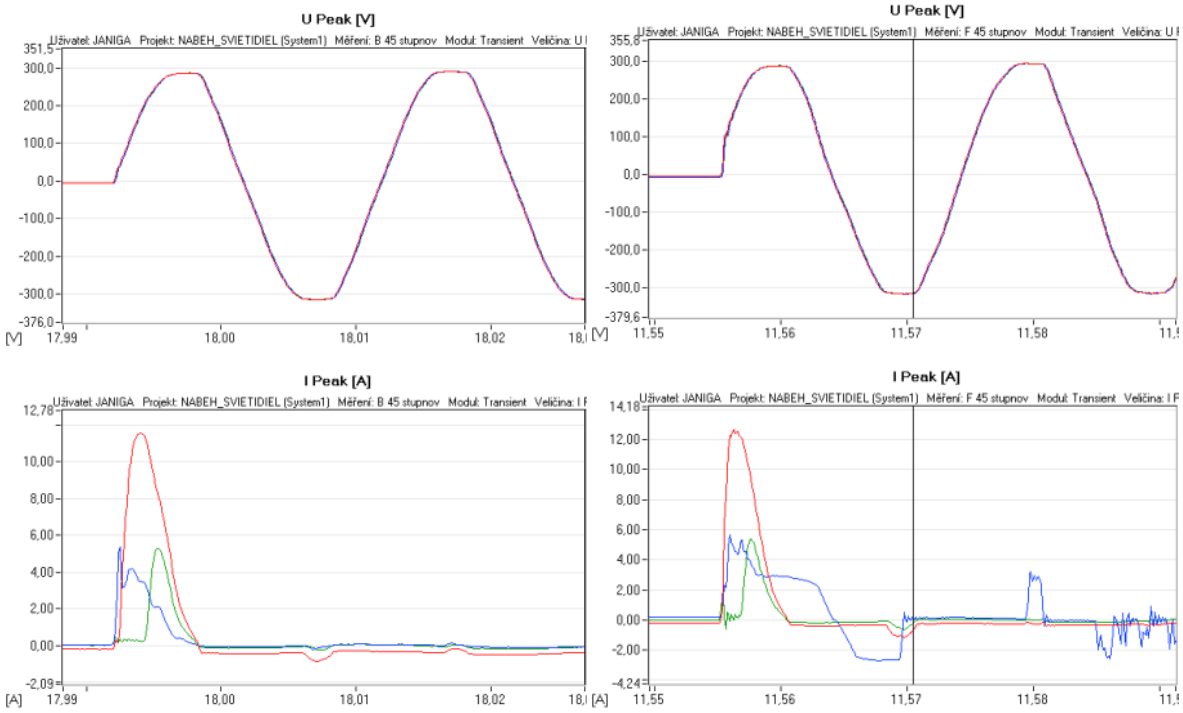


Fig. 2 Current during start. Cold start on upper figures and hot start on bottom figures

Repeated starts may cause overloading and design of installations has switched off protection. These transients may bring about problems with power quality and other device function [2]. In case of repeated starts shortly consecutive, the current peaks increase stress on internal circuit of driver and lamp. This overloading is caused by repeating current peaks. The Fig. 2 shows decreased first current peak during hot start in the case of 2nd lamps.

3. Current peak during lamp start

During the analysis were investigated three different LED lamps and they were analyzed during the switching on transient. Voltages and currents are plot in figures below. Curves of voltages and current are colored, where lamp1 is red, the lamp 2 is green and the lamp 3 is blue. The figures show the impact of voltage phase at start to current behavior. If voltage phase is near 90 degree, the current peak is maximal. Duration of current peak is dependent on capacitor but for reliable operation is no possible to decrease capacity of this capacitor.



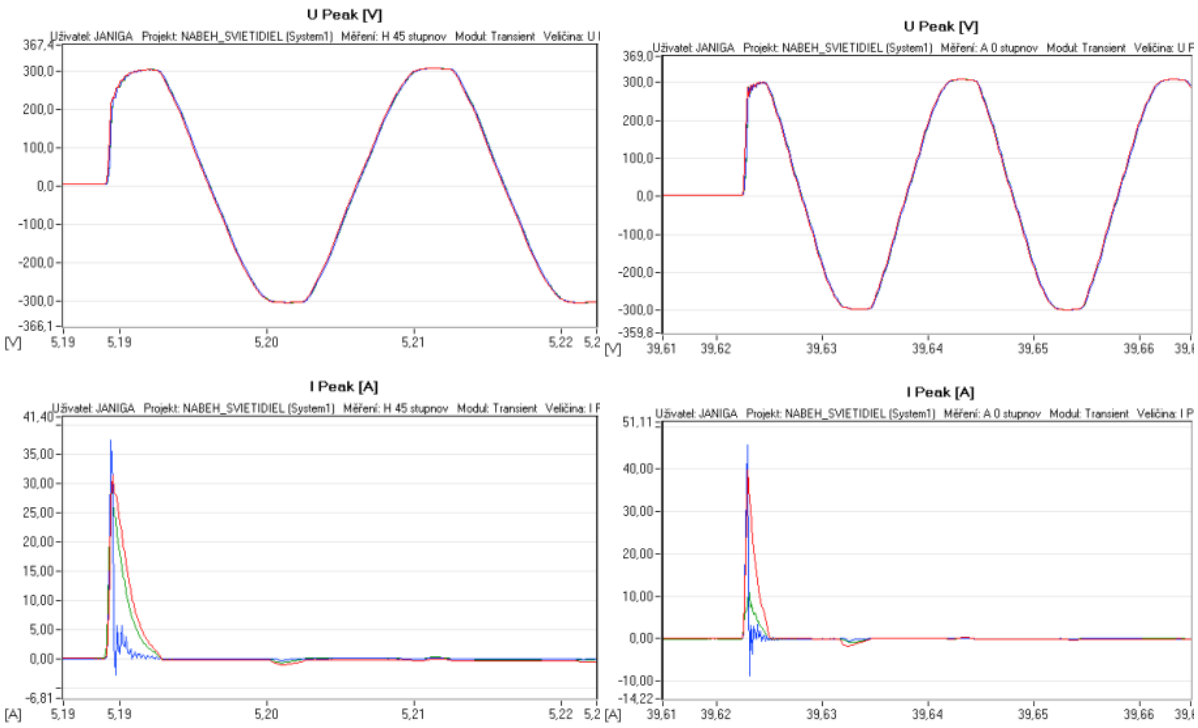
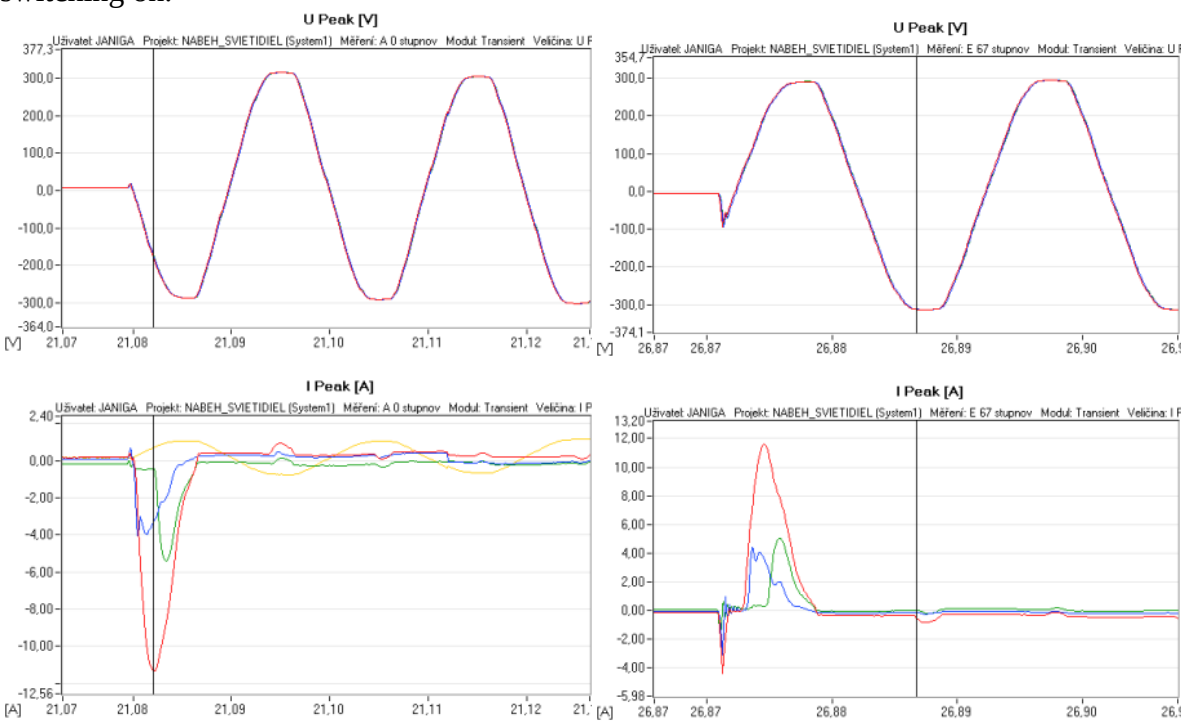


Fig. 3 Change current peak in dependence on phase of voltage

The voltage phase depends on turn on lamp moment. Greater instantaneous voltage during start moment cause greater current peak. Results of measuring shows behavior of lamps with drivers but from measurement is not possible provide general information about start up current. Different drivers generate different behavior of current. If we try to find formula for behavior description during start up, then it is possible to describe like as transient during capacitive load switching on.



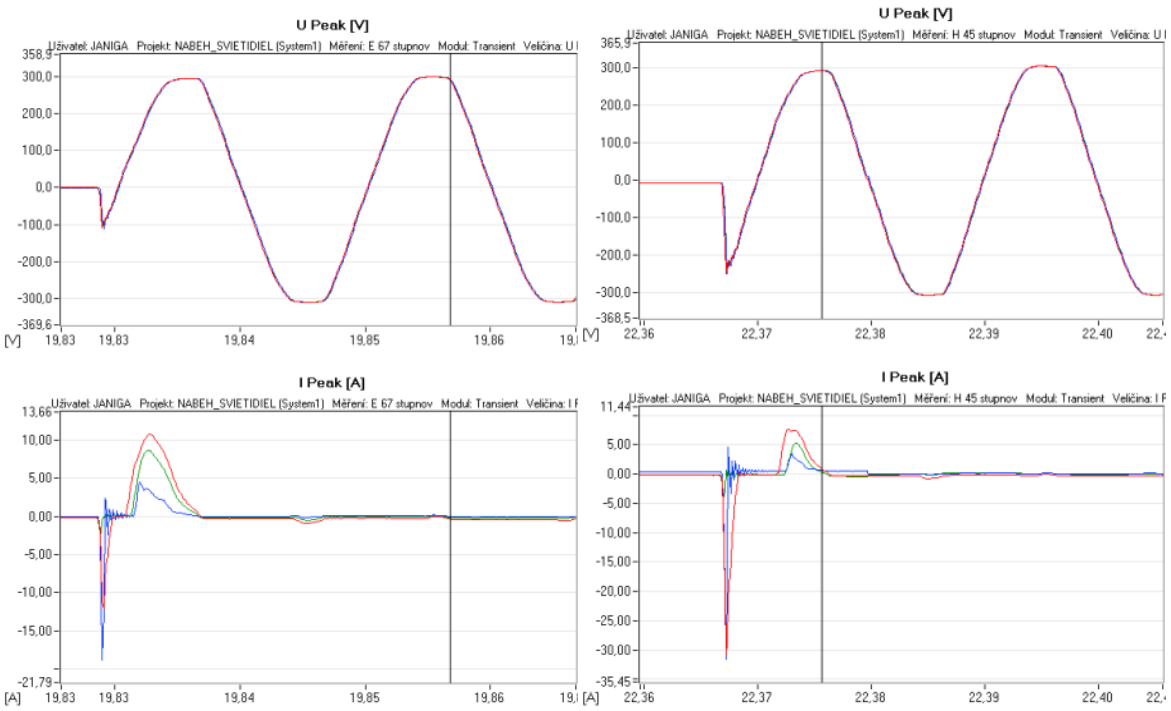


Fig. 4 Change current peak in dependence on phase of voltage (angle from 270 to 360 degree)

Results of investigation of start up current with phase voltage from 180 to 360 degree are showed on Fig. 4. There is interested the behavior around the 180 degree, where voltage cross the axis. In this case is current peak divide to two small peaks. It can decrease current peak during start up of lamp driver.

4. Switching flash

Switching of lamp is solved by switching elements with mechanical switching contacts most often. In consequence the mechanical property of switching contacts is switching flash very often. It is small oscillations of contacts and it cause oscillations of voltage. On Fig. 5 is possible to view these oscillations and oscillations of current too.

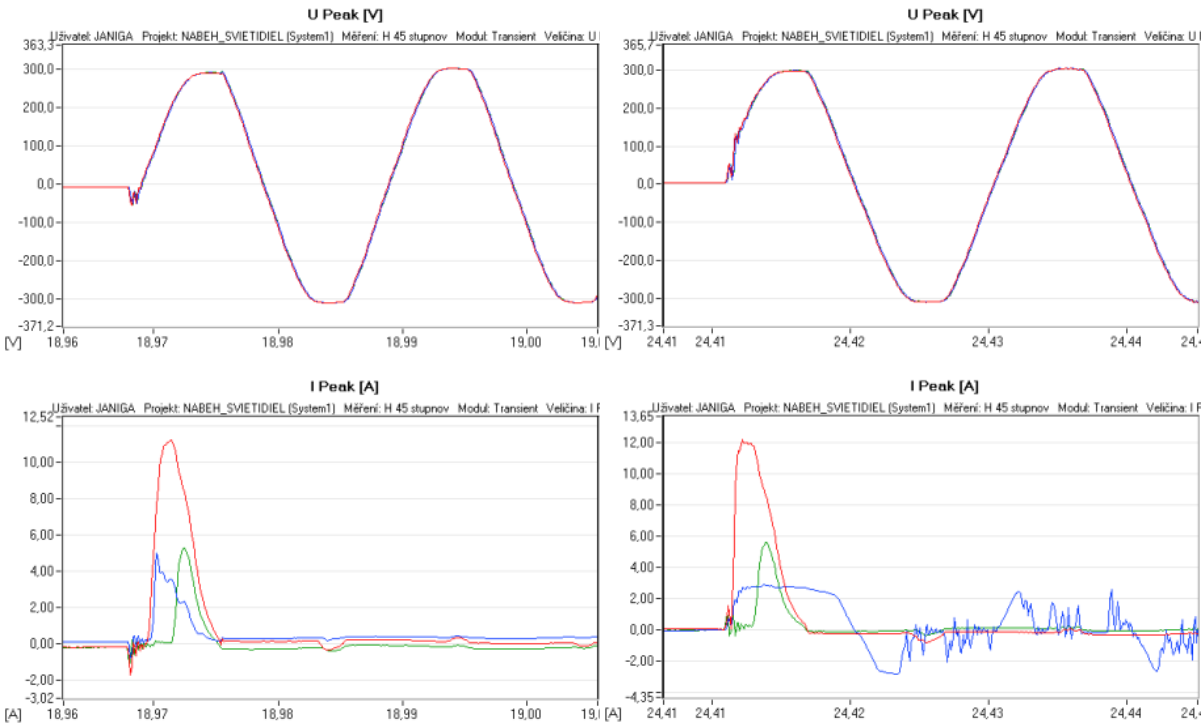


Fig. 5 Change current peak in dependence on relay contact

Semiconductor switching elements can eliminate the problem about switching flash but now is used rarely.[1]

5. Mathematical description of start up current

Calculation of the start up current of LED lamp can be solved in two ways. Comprehensive method is by modelling whole electrical circuit of driver and LED modules. Simply method for start up current calculation is by modelling lamp like capacitive load (capacitor) or inductive load (transformer). This simplification reduces calculation to solving problem switching inductive or capacitive load. Current waveforms during inductive or capacitive load switching are calculated using differential equations. [5]

Inductive load switching

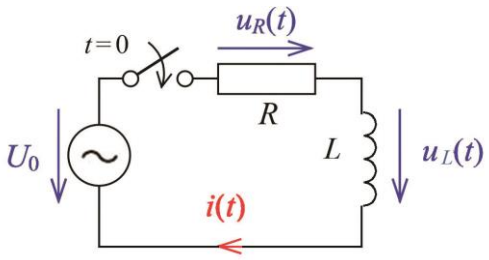


Fig. 6 Simple circuit with switching RL load

Resultant current formula i(t) is calculated:

$$i(t) = \frac{U_{0m}}{Z}\left[\sin(\omega t + \alpha - \delta) - \sin(\alpha - \delta)\, e^{-\frac{R}{L}t}\right]$$

where U_{0_m} – maximum voltage of power supply,
Z – circuit impedance,

ω – angular speed 2πf,
δ – phase difference.

Capacitive load switching

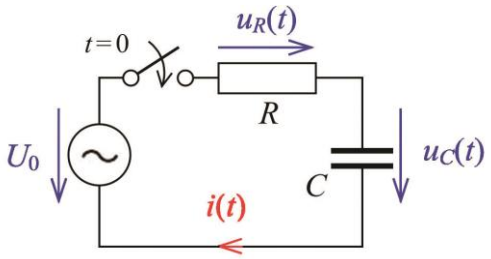


Fig. 6 Simple circuit with switching RC load

$$i(t) = \frac{U_{0_m}}{Z}\sin(\omega t + \alpha - \delta) - \frac{\cos(\alpha + \delta)}{\omega RC}e^{-\frac{t}{RC}}$$

Although capacitor and transformer are located in the DC part of the circuit, description of transient is preferable with formulas for AC circuits. It is due, the voltage in DC circuit copy the voltage on AC during start up (half of period). At the rise time the voltage is in half of period, it is still unidirectional, and it has sinusoidal shape.

Conclusions

LED lamps using is increasing in field of interior and exterior lighting. It is reason why is LED lighting topic more often discussed. Exercitation of LED lamp shows problems of this technology. Some problems have electrical character. One of them is startup current. It is difficulty identifiable by electrical engineering without special measuring equipment because startup current is very fast with high current peak. This paper show results of measuring of startup current and it give information about this problem.
Aim of this paper is also describe methodology of calculation startup current. Exactly calculation of current peak is difficult and for calculation is necessary information about all components of lamp. Paper describes simplified calculation which gives information about current behavior during startup.

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